Population Surveys of the Soft-shell Clam (*Mya arenaria*) in Selected Estuaries on the Eastern Shore of Nova Scotia, 1981

by

Nancy B. Witherspoon

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Abstract

Soft-shell clam population surveys were conducted at Chezzetcook and Sonora harbours on the Eastern Shore of Nova Scotia, during the summer of 1981. Results of estimates of standing stocks, size frequency distributions and growth rates from both locations are given. Historical information on landings and recent catch and effort data are documented. Some management proposals are presented.

1. Introduction

The soft-shell clam fishery on the Eastern Shore of Nova Scotia is thought to comprise a substantial portion of the total harvest in the province. However, statistics on landings in this fishery are underestimates of the actual catch. This is because much of the catch is transported away from the area for processing, while the remainder is sold privately or dug recreationally, and therefore is not reported by sales slips.

Prior to the 1950's, a number of clam plants operated successfully along the Eastern Shore, supported by large catches. It is believed that overfishing reduced stock size and harvest; subsequently, the economic feasibility of the processing plants declined resulting in their closure. Since that time overall stock abundance has remained relatively low with only periodic increases. Lacking proper management, except for a 49 mm (2 in.) size limit, these periodic rises in stock abundance were paralleled by increased fishing intensity, until abundance again declined. Presently, the fishery appears to be in another period of higher stock densities.

Historically, the Eastern Shore has been an area where natural resources have been the primary industry. Population numbers have been low and secondary industrial development nearly absent. Recently, concerns have been expressed as to the future direction of its growth and development and the resultant impact on its natural resources.

The surveys detailed herein were instituted by the provincial government in response to these concerns, in order to document the present size and exploitation rate of the clam resource, its value, the number of people employed, and a prediction of its future status. In addition, information was to be collected on important biological variables such as growth rates and reproduction.

2. Methods

2.1 Field Procedures

Field work was conducted between May 20 and September 3, 1981. Initially, five areas of commercial and recreational importance - Chezzetcook Harbour, Sonora, Musquodoboit Harbour, Clam Harbour and Petpeswick Inlet - were to be surveyed. However, due to manpower and time limitations, and the extent and nature of the clam flats, only the first two areas of priority were completed.

Survey techniques were basically identical to those used by Fisheries and Oceans (Robert, 1979). A fourteen foot aluminum boat with a six horsepower motor transported two two-men crews and their equipment to the clam flats. Only those flats commercially dug or having at least 10 clams per 1 ft.^{2} (.09 m^2) were surveyed. One square foot was chosen as a manageable and representative plot size for digging and sampling clams.

A basepoint was located in the centre or at the end of a flat, using a Silva Safari Type 16 compass by taking bearings (magnetic) on two prominent land features found on

Lands and Forests orthophoto maps (scale 1:10,000). A baseline was established through the basepoint, in a compass direction dependent on the shape of the flat, and stakes were driven at regular intervals of either 15 or 30 m (50 or 100 feet) along this line, gauged by a marked rope. Transect lines could then be established parallel to the baseline, at either 15 or 30 m apart. The distance between stakes and lines was dependant on the density distribution of the clams on the flat and the size of the flat. Usually, if distribution was homogeneous and the flat large, the distance chosen was 30 m. Transect lines ended where clam densities were near zero and distances from the last stake to these points were walked off or measured with the rope.

At each stake, or station, a plot 1 ft.^{2} (.09 m^2) and 20 cm deep (maximum depth to which soft-shell clams are found) was dug with a square-nose shovel. Each sample was screened through a plastic fisherman's basket lined with a 6.4 mm (1/4") plastic mesh. All clams were retained and put into marked plastic bags. Later, length measurements (long axis) to the nearest millimeter were made using vernier calipers.

Five appropriate locations were chosen for collection of clams for aging purposes. These locations were separated physically and appeared to be different environmentally. More than 150 clams of a wide size range were selected from each location. Each sample was placed in a labelled plastic

bag and then frozen.

While in the field, incidental information on the fishery was recorded. Number of diggers was noted in an area on a daily basis. Interviews with fishermen allowed collection of data on catch and effort including number of buckets (2 gallon traditional harvesting unit) and hours dug per tide, as well as information on past digging success and changes in availability of flats for digging.

Historical clam landing data was obtained from Fisheries and Oceans, Statistics Division, and 1978-1981 landing information, from clam buyers and fisheries officers. In Chezzetcook Harbour, where landing statistics are not available, total harvests were estimated by multiplying average buckets per tide times average number of diggers per tide, times average number of dug tides per month, times average number of months dug per year. Although rough estimates, these figures seemed to agree reasonably well with known incomes of diggers and may even be underestimates, based on similar calculations for Sonora where buyer-reported catches are known.

2.2 Treatment of Samples

2.2.1 Map Work

Once survey work on a particular flat was completed (each flat or "area" was given a number), stations were marked on a 3x enlargement of the Lands and Forests maps. When all areas were mapped, the size of each was calculated in square feet, square metres, and acres.

Table 1. Number of soft-shell clams per bushel at selected sizes (from MacPhail & Medcof, 1955).

Size (length) mm	inches	Clams per bushel
36-41	1 1/2	2800
42-48	1 3/4	2200
49-54	2	1600
55-60	2 1/4	1180
61-67	2 1/2	920
68-73	2 3/4	700
$\geq$74	$\geq$3	560

Table 2. Statistical parameters of the log-log regression of shell width (mm) on shell length (mm) for soft shell clams on the Eastern Shore, 1981.

$$\log (\text{shell length}) = \log \alpha + \beta \log (\text{shell width})$$

Location	n	α	β	95% confidence limits α		β		r^{2*}
W Chezzetcook (area # 6)	165	.2266	.993	.2028	.2505	.976	1.010	.994
NE Chezzetcook (area #24 & 25)	165	.2197	.997	.1959	.2436	.979	1.015	.993
SE Chezzetcook (area #12a, 12b, 13, 14)	157	.2065	1.009	.1783	.2346	.988	1.031	.991
NE Sonora (Area #3)	255	.2492	.972	.2280	.2704	.955	.988	.991
SW Sonora (Area #4)	241	.2407	.981	.2158	.2657	.962	1.000	.988

* correlation coefficient

2.2.2 Numerical Tabulation

2.2.2.1 Stock Assessment

All clams measured were placed into 1/4" size classes (mm equivalents) and then into groups: Juveniles $\leq$ 1 1/4" ($\leq$ 35 mm), Prerecruits 1 1/2-1 3/4" (36-48 mm), and Markets $\geq$ 2" ($\geq$ 49 mm). This was done for the three locations, West Chezzetcook (areas 1-18), Northeast Chezzetcook (areas 1-6, 24 & 25), and Southeast Chezzetcook (areas 7-23), in Chezzetcook Harbour, and for the two locations, Northeast Sonora (areas 1 & 3) and South Sonora (areas 2 & 4), at Sonora. For all areas and locations, tables of size, numbers of stations, and clams measured were summarized. In addition, calculations of size classes and groups within locations for numbers of clams per 1 ft.^{2} (.09 m^2), percentages of the total, bushels per acre, and total production (bushels), were completed. Bushel (bu) computations were made for only prerecruits and markets, using clams per bushel in 1/4" size classes, from MacPhail and Medcof (1955) (Table 1). Inches and bushels are used in calculations because they were historically and still are acceptable units for expressing size and quantities of clams in both scientific and processing fields. Graphs are presented to illustrate observed differences in size frequency distributions.

2.2.2.2 Determination of Growth Rates

Growth information was collected as part of baseline data necessary for future more complete stock assessments. Using estimates of fishing and natural mortality rates from

fished and unfished populations respectively, plus growth parameters from the von Bertalanffy growth equations, it is possible to calculate whether a stock in a particular area is being overfished or underfished. This information can then be used to determine approximate harvesting rates and management measures.

Clams collected for aging were thawed, cleaned, dried and then aged by marking etches or "rings". These rings were usually apparent as a dip or notch in the shell surface, but location of them was often aided by holding the outside of the shell to a lamp and noting areas of light transmission. Ring 0 is laid down over the first winter and is not measured since it is usually worn and difficult to see. Ring 1 is the first ring which represents a full years growth and is probably somewhere between 1.5 - 1.7 years old. Therefore, a one year old is considered to be any animal with a length between Ring 1 and Ring 2. This methodology has been applied and compared to actual growth in the field, with similar results, by both Newcombe (1936) and Brousseau (1979).

Growth rings are best measured in shell width; therefore shell widths must be converted to shell lengths for fitting to a von Bertalanffy growth curve. Growth may be described as an allometric equation

$$\text{length} = \alpha(\text{width})^{\beta}$$

or log (shell length) = $\alpha + \beta$ (shell width) the linear function. Then α equals the intercept on y axis constant and β equals the slope of the line.

Table 2 gives the statistical parameters of this equation for the five locations where clam samples were collected. After widths were converted to lengths, a von Bertalanffy growth curve was fitted to the unweighted estimates of mean length at age (Allen, 1966, 1967) using the equation

$$L_t = L_\infty \ (1-e^{-k(t-t_o)})$$

where L_t = given length

L_∞ = length at which the rate of growth is zero

k = rate of growth to L_∞

t = age at given length

t_o = age at which length is zero

Tables 13 and 14 list the parameters of the growth equations with confidence limits and standard error for each location. Fitted and measured length at age are presented in Appendix 3.

3. Results

3.1 Chezzetcook Harbour

3.1.1 Physical Setting

Chezzetcook Harbour is located 40 kms east of Halifax (Figure 1) and is approximately 10 kms long. It is an important area to survey since it is one of the few remaining salt marsh estuaries in Nova Scotia that has not been reclaimed for farming (Hatcher and Patriquin, 1981), and therefore supports rich and varied plant and wildlife commun-

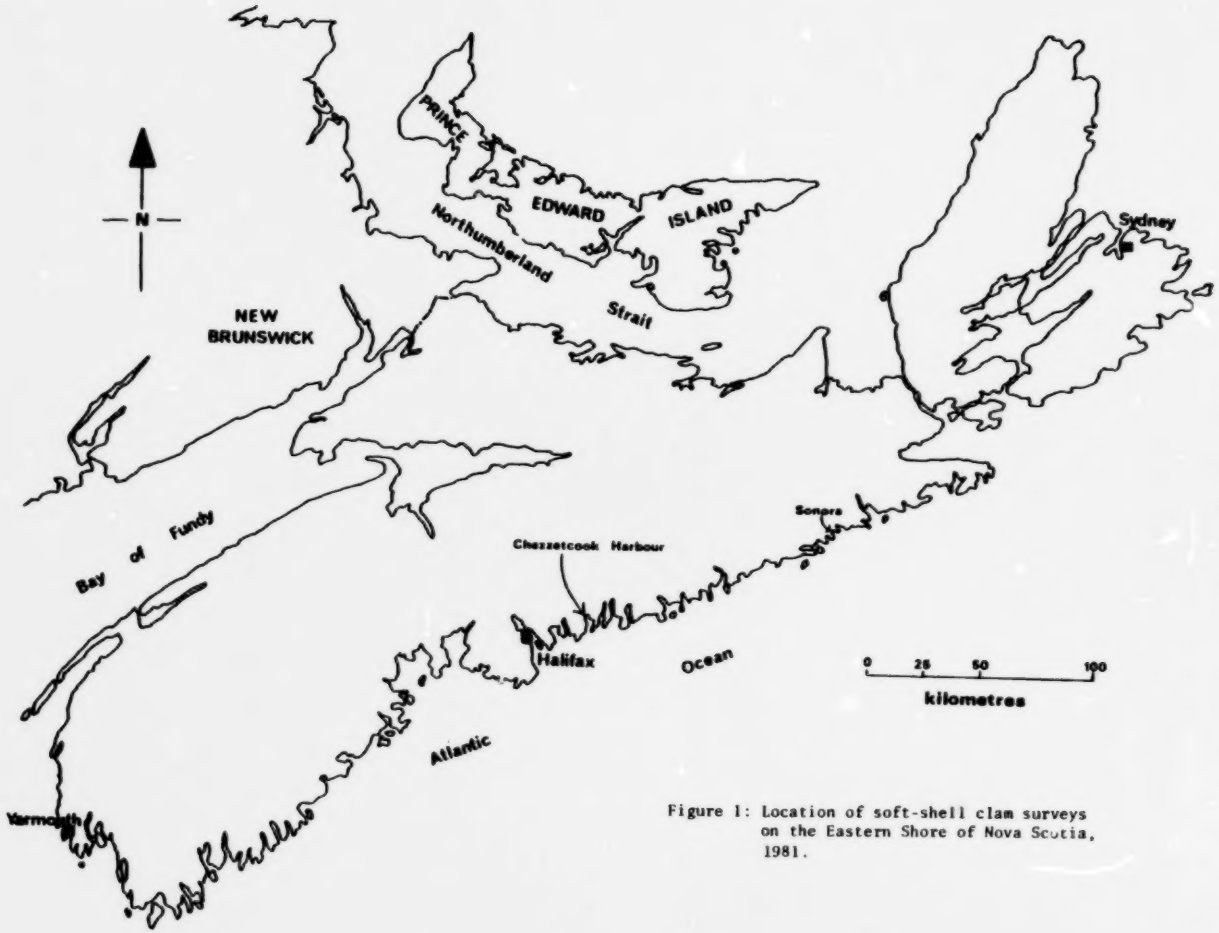

Figure 1: Location of soft-shell clam surveys on the Eastern Shore of Nova Scotia, 1981.

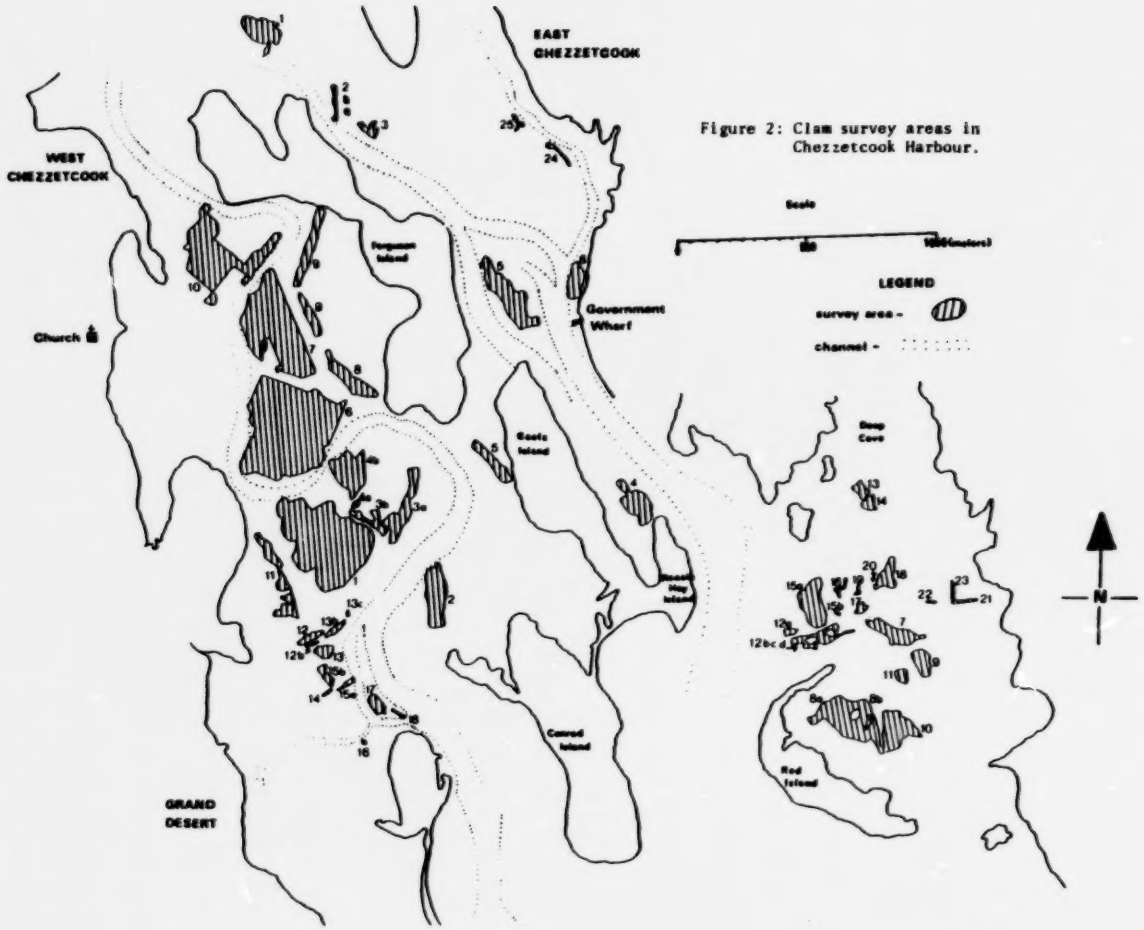

Figure 2: Clam survey areas in Chezzetcook Harbour.

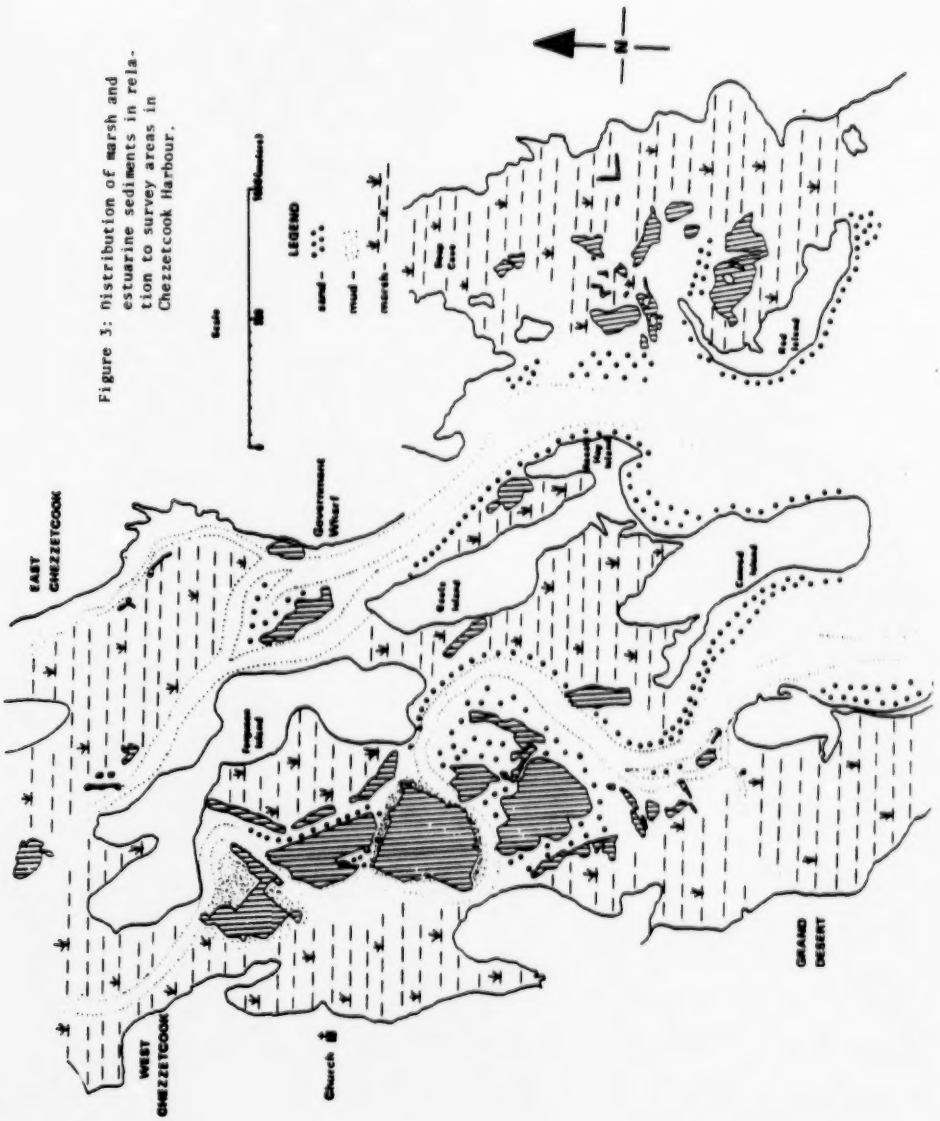

Figure 3: Distribution of marsh and estuarine sediments in relation to survey areas in Chezzetcook Harbour.

ities. The harbour is physically divided into West (W) and East (E) Chezzetcook by a string of islands. Only the lower half of the estuary has significant clam flats and therefore this is the area that was surveyed (Figure 2). The clam flats on the west side are extensive and separated by one major winding channel and numerous minor channels, some of which are dry at low tide, and areas of marsh grass (Spartina alterniflora) and eel grass (Zostera marina) pools (Figure 3). Both mud flats and sand flats are found. On the east side, the flats are much smaller and more numerous, consisting mostly of sand. The channels are fewer and larger, and areas of marsh and eel grass are more widespread. Clam flats on this side seemed to be lower in the tidal range than those on the west side and therefore, quite often the edges of the flats were submerged and not accessible for digging. On both sides of the harbour, clams were located mainly in the middle half of the tidal range. Larger animals occurred towards the low tide mark and high densities of young clams were found in the upper reaches. Distribution of clams on the flats was usually patchy; i.e., areas or bands with higher densities were observed. This was particularly true on the large flats.

3.1.2 Commercial Fishery

Clams are dug commercially in Chezzetcook Harbour from March to November, although this is dependent on snow and ice conditions. A bent-over pitch fork, known as a

Table 3. Acreage surveyed, number of areas, number of stations, and number of clams measured for the three locations in Chezzetcook Harbour.

Location	Acreage*	Number of Areas	Number of Stations	Number of Clams
W Chezzetcook	98.95	24	592	13,994
NE Chezzetcook	14.42	8	120	3,394
SE Chezzetcook	23.80	19	218	7,460
Total	137.17	51	930	24,798

* 1 acre = .41 hectare

Table 4. Average number/ft.^{2} (.09 m^2) and percentage size frequency distribution of clams sampled in Chezzetcook Harbour for all locations combined.

Group	Size Class (inches)	(mm)	Average number/ft.^{2}	Total	Percentage of total number	Total %
Juveniles	<3/4	0-16	4.71		18	
	3/4	17-22	5.97	19.75	22	74
	1	23-29	5.65		21	
	1 1/4	30-35	3.42		13	
Prerecruits	1 1/2	36-41	2.60	4.80	10	18
	1 3/4	42-48	2.20		8	
Markets	2	49-54	1.18		4	
	2 1/4	55-60	0.62		2	
	2 1/2	61-67	0.26	2.16	1	8
	2 3/4	68-73	0.08		<1	
	≥3	≥74	0.02		<1	
Total			26.71		100	

clam rake, is the usual instrument for digging, while shovels are sometimes employed. Clams greater than or equal to 49 mm (2") may be harvested. There are approximately 10 full time diggers who live locally and sell their clams, mostly shucked, to local restaurants in Halifax and area. Since there is no central buyer, statistical records of landings from this area are not available. In the summer the number of diggers increases significantly, as students and vacationers get involved. Access is limited to those who have boats and to times when waters are not rough, particularly at West (W) and Southeast (SE) Chezzetcook; therefore, effort is less in these places than it might be. Major flats of commercial importance in W Chezzetcook in ranked order are 6, 1, 7, 10 and 13-15, and in Northeast (NE) Chezzetcook, 6, 5, 1, 24 and 25. Very limited effort was observed in SE Chezzetcook.

3.1.3 Stock Assessment

A summary of sampling information for the combined acreages of all areas, by location, is presented in Table 3 (Appendix 1 has the detailed figures for the areas in Tables A1.1 - 1.3). W Chezzetcook has more than two times the acreage available for commercial harvest of clams than E Chezzetcook (Table 3). Of the three locations, NE Chezzetcook had the lowest total acreage. Table 4 contains a summary of average numbers per 1 ft.^{2} (.09 m^2) and percentage size frequency distributions for all of Chezzetcook combined. (Appendix 1, Tables A1.4 - 1.9, has more details

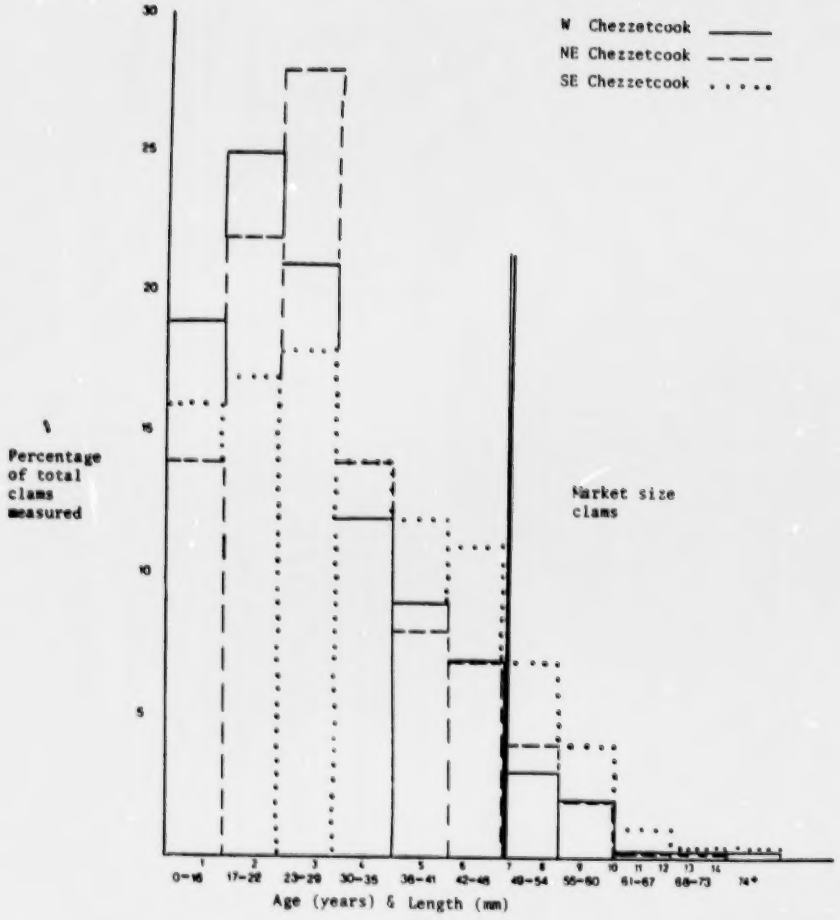

Figure 4. Percentage of total clams measured by size class and age in three locations in Chezzetcook Harbour.

Table 5. Summary of number/ft.^{2} (.09 m^2) and percentage size frequency distribution for the three locations in Chezzetcook Harbour.

Group	W Chezzetcook Number/ ft.2	%	NE Chezzetcook Number/ ft.2	%	SE Chezzetcook Number/ ft.2	%
Juveniles	18.35	77	22.06	78	22.23	65
Prerecruits	3.69	16	4.36	15	8.06	23
Markets (≥2")	1.51	7	1.86	7	4.10	12
Total	23.55	100	28.28	100	34.39	100

Table 6. Estimated bushels/acre of prerecruits and markets for individual locations and all locations combined in Chezzetcook Harbour.

Group	W Chezzetcook bu/acre	NE Chezzetcook bu/acre	SE Chezzetcook bu/acre	Total bu/acre
Prerecruits	64.3	76.4	142.0	84.0
Markets	51.9	62.0	138.2	73.6
Total	116.2	138.4	280.2	157.6

of this data by area.) Size class 17-22 mm predominates all others and is followed by a decline into market size clams (Table 4). Those less than 17 mm are likely underestimated due to the selectivity of the mesh basket liners. Seventy four percent of the total number of clams were juveniles and of these it appears the 1978-1980 year classes were very strong (Figure 4). Five to seven years from now (1986-1988), harvests should be very good. The next three years should see fair recruitment into the commercial fishery. Harvesting pressure appears to be moderate to heavy with a relatively low percentage of market size clams. Table 5 illustrates densities and size frequency distributions by location. E Chezzetcook Harbour had higher densities of all size groups. SE Chezzetcook had double the numbers of prerecruits and markets, compared to other locations (Figure 4). These phenomena may be a result of lower fishing effort on the east side of the harbour, particularly in SE Chezzetcook. Of interest is the slightly lower numbers of juveniles on the west side, which may be caused by smothering of clams through digging. Total average densities (Table 5) for SE Chezzetcook are considered high, while the other locations are considered moderate in comparison to the results from similar surveys carried out in the Maritimes (Robert, 1979, 1981). Bushels per acre (Table 6) calculations were used to estimate total production or potential harvest, while a measure of numbers per 1 ft.^{2} (.09 m^2) was found to be a parallel indicator of the status of stocks

Table 7. Estimated production (bushels)* of soft-shell clams in three locations in Chezzetcook Harbour.

Group	W Chezzetcook bushels	NE Chezzetcook bushels	SE Chezzetcook bushels	Total bushels
Prerecruits	6,362.5	1,100.0	3,380.2	10,842.7
Markets	5,135.5	894.9	3,288.8	9,319.2
Total	11,498.0	1,994.9	6,669.0	20,161.9

*One bushel = 60 lbs. or 27 kgs. shell weight = $16.00 landed value

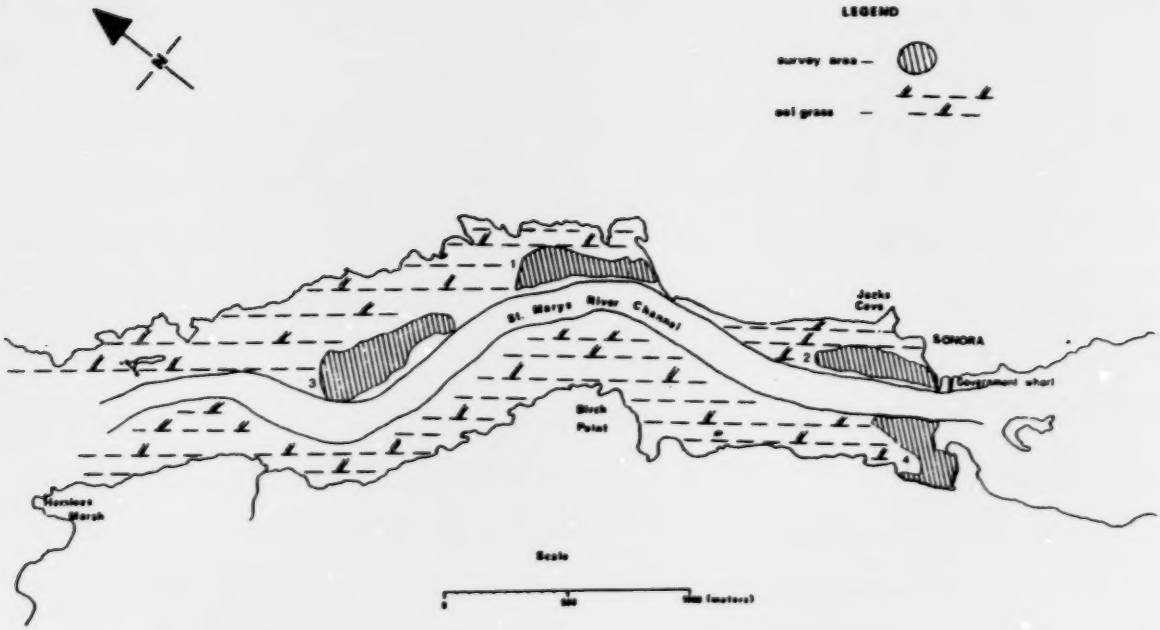

Figure 5: Clam survey areas and eel grass distribution at Sonora.

in the different locations. Two hundred and eighty bushels per acre in SE Chezzetcook is considered to be a very high production figure. W Chezzetcook had the largest potential production of market size clams (5,135.5 bushels), primarily because of the greater total size of clam flats (Table 7).

3.2 Sonora

3.2.1 Physical Setting

Sonora is located at the mouth of the St. Mary's River, 12 kms from the village of Sherbrooke which is approximately 200 kms east of Halifax (Figure 1). This estuary consists of one relatively straight and wide channel. The clam flats lie adjacent to both sides of the channel, are approximately 50 - 200 m wide, and are drained by narrow waterways known as guzzles. Behind them are large wet areas filled with eel grass which extend to the shore (Figure 5). There is little marsh grass found in this part of the estuary. Clam flats are lower here than at Chezzetcook which allows only an average of two hours of digging per tide as compared to three in Chezzetcook Harbour. This particular situation was aggravated this year since low tides were higher than average, and as a result some of the flats on the W and NE sides were not surveyed. Clam distribution on the flats was relatively homogeneous from the low to high tide marks. Fishermen reported that very large clams could be found during extremely low tides along the edge of the channel.

3.2.2 Commercial Fishery

There were approximately 10 full time diggers participating in the clam fishery at Sonora this year between

Table 8. Acreage surveyed, number of areas, number of stations, and number of clams measured for the two locations at Sonora.

Location	Acreage*	Number of Areas	Number of Stations	Number of Clams
NE Sonora	33.77	2	136	1,919
S Sonora	22.87	2	92	1,070
Total	56.64	4	228	2,989

* 1 acre = .41 hectare

Table 9. Average number/ft.^{2} (.09 m^2) and percentage size frequency distribution of clams sampled at Sonora for all locations combined.

Group	Size Class (inches)	(mm)	Average number/ft.^{2}	Total	Percentage of total number	Total
Juveniles	<3/4	0-16	1.68		13	
	3/4	17-22	1.87	6.97	14	53
	1	23-29	2.01		15	
	1 1/4	30-35	1.41		11	
Prerecruits	1 1/2	36-41	1.45	3.55	11	27
	1 1/3	42-48	2.10		16	
Markets	2	49-54	1.46		11	
	2 1/4	55-60	0.71		5	
	2 1/2	61-67	0.36	2.58	3	19
	2 3/4	68-73	0.04		<1	
	≥3	≥74	0.01		<1	
Total			13.10		100	

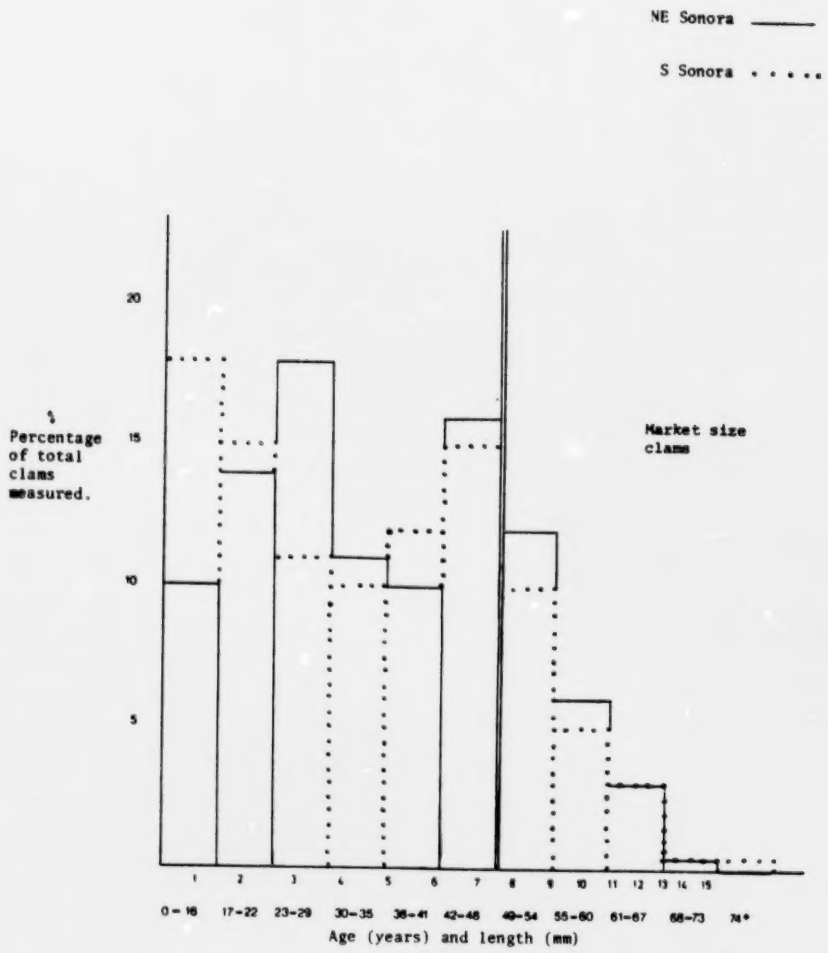
NE Sonora
S Sonora
% Percentage of total clams measured.
Market size clams
20
15
10
5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
0-16 17-22 23-29 30-35 36-41 42-48 49-54 55-60 61-67 68-73 74+
Age (years) and length (mm)

Figure 6: Percentage of total clams measured by size class and age in 2 locations at Sonora.

April and November. Local school children were involved during the summer; in addition, the area was frequented by recreational diggers because of its easy accessibility and good catches. Clams 49 mm (2") and above were sold in the shell to a local buyer, after which they were shipped to New Brunswick for processing. As with Chezzetcook, fisheries statistics are unreliable for this area since the clams are not processed locally. The major clam flats are areas 1 and 2 (Figure 5), which are very accessible from shore and therefore are quite intensely fished. On the west side, area 4 and clam flats opposite area 1 are less intensely fished since access is by boat only, and flats are lower and therefore less often exposed. Distance, necessity for a boat, and lack of rough waters makes harvesting pressure of area 3 and other flats to the north, lowest for Sonora.

3.2.3 Stock Assessment

The four areas surveyed at Sonora were grouped into two locations, NE (areas 1 & 3) and South (S) Sonora (areas 2 & 4), based on similarities in length frequency distributions. A summary of the sampling information is presented in Table 8, with further details in Appendix 2 (Tables A2.1 - 2.5). NE Sonora had slightly higher acreage than S Sonora. Table 9 illustrates density and percentage frequency distribution for both locations combined. The population appears to be bimodal with two peaks, occurring at 23-29 mm and 42-48 mm (Figure 6). Fifty-three percent of the total

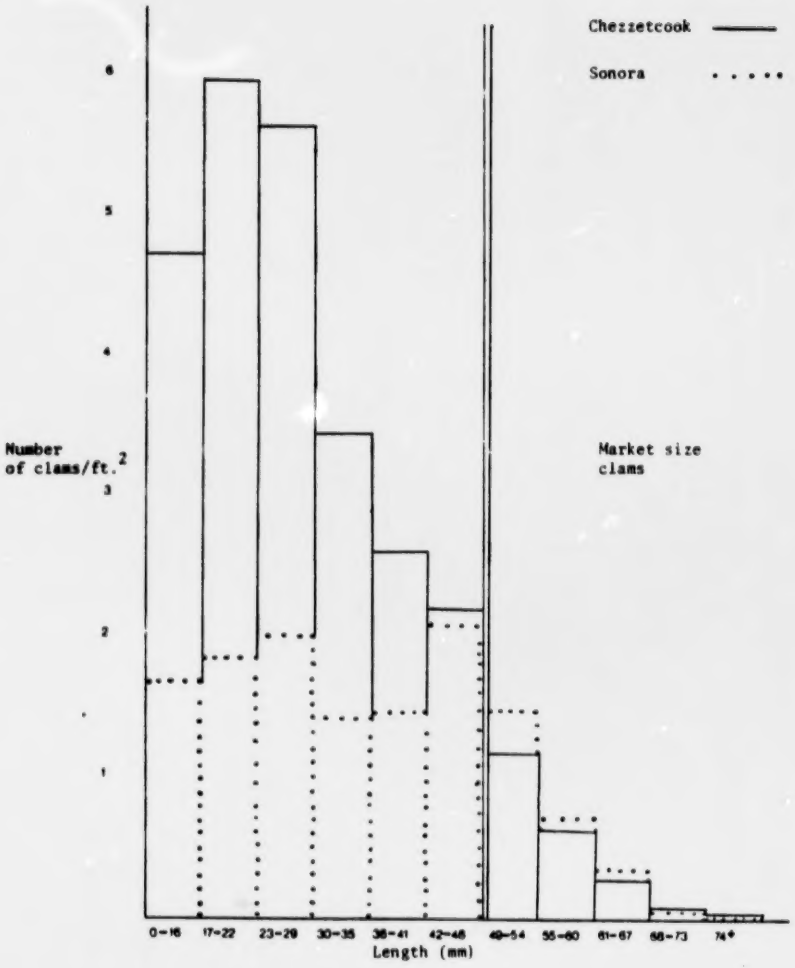

Figure 7: Number of clams/ft.^{2} by size class for both Chezzetcook Harbour and Sonora.

Table 10. Summary of number/ft.^{2} (.09 m^2) and percentage size frequency distribution for the two locations at Sonora.

		NE Sonora				S Sonora			
Group	Size class (mm)	Average number/ft.^{2}	Total	%	Total	Average number/ft.^{2}	Total	%	Total
Juveniles	0-16	1.40		10		2.10		18	
	17-22	1.99	7.50	14	53	1.71	6.22	15	54
	23-29	2.54		18		1.24		11	
	30-35	1.57		11		1.17		10	
Prerecruits	36-41	1.45	3.75	10	26	1.45	3.24	12	27
	42-48	2.30		16		1.79		15	
Markets	49-54	1.66		12		1.17		10	
	55-60	0.79		6		0.59		5	
	61-67	0.38	2.87	3	21	0.33	2.17	3	18
	68-73	0.04		<1		0.05		<1	
	≥74	0.00		0		0.03		<1	
Total		14.12		100		11.63		100	

Table 11. Estimated bushels/acre of prerecruits and markets for individual locations and all locations combined at Sonora.

Group	NE Sonora bu/acre	S Sonora bu/acre	Total bu/acre
Prerecruits	68.1	58.0	64.0
Markets	94.3	75.0	86.0
Total	162.4	133.0	150.0

population consisted of juveniles which is considered a fair to good production of young. However, it is substantially lower than Chezzetcook (Figure 7) and densities of juveniles per 1 ft.^{2} (.09 m^2) were 6.97 at Sonora as compared to 19.75 in Chezzetcook. There are slightly fewer prerecruits here than at Chezzetcook and slightly higher numbers of markets. These densities are considered moderate as compared to another area surveyed in the Maritimes (Robert, 1979). In comparing densities by location (Table 10, Figure 6) it is shown that NE Sonora has higher densities on the average than S Sonora. This is probably a result of lower fishing intensity, (thereby reducing indirect fishing mortality through smothering), and possibly because of better environmental conditions and therefore improved juvenile survival (notably in area 3 (Table A 2.6)). Total bushels per area production (Table 11) is high compared to other areas in the Maritimes (Robert and Smith, 1980) and markets ranked moderate to high (Robert, 1981). Production also appears to be greater upstream than downstream. The numbers of bushels of potentially harvestable market size clams was 4,900 (Table 12), approximately half of that available at Chezzetcook Harbour, which had more than double the amount of acres. Therefore, overall potential production per unit area at Sonora was greater than at Chezzetcook. This may be partially a reflection of the reduced harvest time at Sonora. The lower bushels per acre of prerecruits at Sonora may be indicative of lower production of young and/or harvest-

Table 12. Estimated production (bushels)* of soft-shell clams in two locations at Sonora.

Group	NE Sonora bushels	S Sonora bushels	Total bushels
Prerecruits	2,299.9	1,326.5	3,626.4
Markets	3,185.5	1,714.8	4,900.3
Total	5,485.4	3,041.3	8,526.7

* One bushel = 60 lbs. or 27 kg. shell weight = $16.00 landed value

Table 13. Parameters for von Bertalanffy growth equations for soft - shell clams from the Eastern Shore, 1981.

$$L_t = L_\infty \ (1-e^{-k(t-t_o)})$$

Location	n	L_∞	k	t_o
W Chezzetcook (Area #6)	788	127.880	.063	-.688
E Chezzetcook NE Chezzetcook (Area #24&25)	600	84.837	.110	-.407
SE Chezzetcook (Area #12a, 12b, 13 & 14)	659	94.198	.097	-.352
Sonora NE Sonora (Area #3)	806	99.842	.088	-.378
SW Sonora (Area #4)	781	105.391	.071	-.804

n = number of rings read

Table 14. 95% confidence limits and standard error of estimates of parameters for von Bertalanffy growth equations from Table 13.

	95% confidence limits						standard error		
Location	L_∞		k		t_o		L_∞	k	t_o
W Chezzetcook	120.505	135.254	.058	.068	-.738	-.637	3.763	.0025	.0259
NE Chezzetcook	79.531	90.142	.100	.121	-.473	-.341	2.707	.0055	.0339
SE Chezzetcook	85.755	102.642	.084	.111	-.450	-.254	4.308	.0069	.0499
NE Sonora	94.281	105.403	.081	.095	-.420	-.336	2.837	.0036	.0216
SW Sonora	99.750	111.031	.065	.076	-.850	-.757	2.878	.0027	.0237

ing of clams below legal size.

3.3 Musquodoboit, Clam and Petpeswick Harbours

3.3.1 Commercial Fishery

Although surveys were not carried out in these areas, some information relevant to the clam fishery on the Eastern Shore was collected. In Musquodoboit, Clam and Petpeswick Harbours there were 10, 9 and 2 people, respectively, digging on a regular basis from April through to September. Two buyers, one from New Brunswick and the other from Nova Scotia, purchased the catch which was sold in the shell. Again, statistics do not reflect true landings in these harbours. Numbers of buckets per tide per person in Musquodoboit Harbour averaged approximately 15 and were thought to be close to this figure in Clam Harbour. Average tides in these harbours are three hours long. Price per bucket ranged from $4.00 to $4.50.

3.4 Growth

Von Bertalanffy parameters are presented in Table 13, with confidence limits and standard errors summarized in Table 14. Growth rates are generally lower than those reported in other areas of the Maritimes. It takes 6 to 7 years for clams to reach market size on the Eastern Shore, whereas in P.E.I. the average age is 5 (Robert, 1981). Medcof (1949) reported 8 years to market size at Five Islands, and 5 to 6 years at Economy Pt. (Robert, 1981) in Minas Basin of the Bay of Fundy. Variability in growth throughout the Maritimes may be a result of differences in local environmental conditions. Even in Chezzetcook Harbour lower

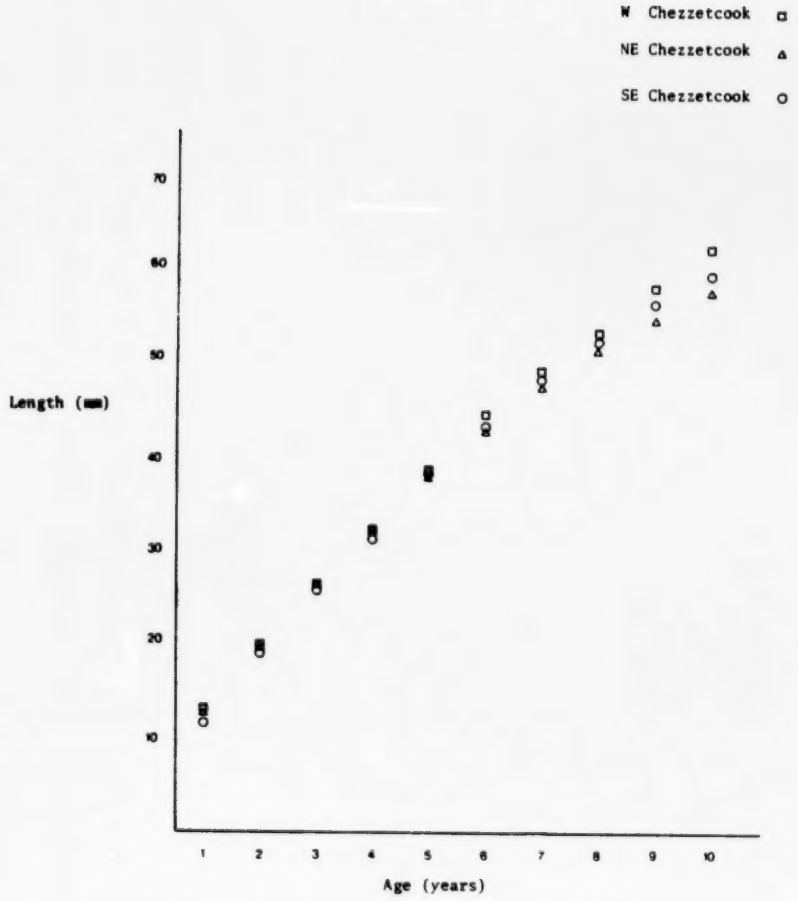

Figure 8: Growth curves for three locations in Chezzetcook Harbour fitted by the von Bertalanffy growth equation.

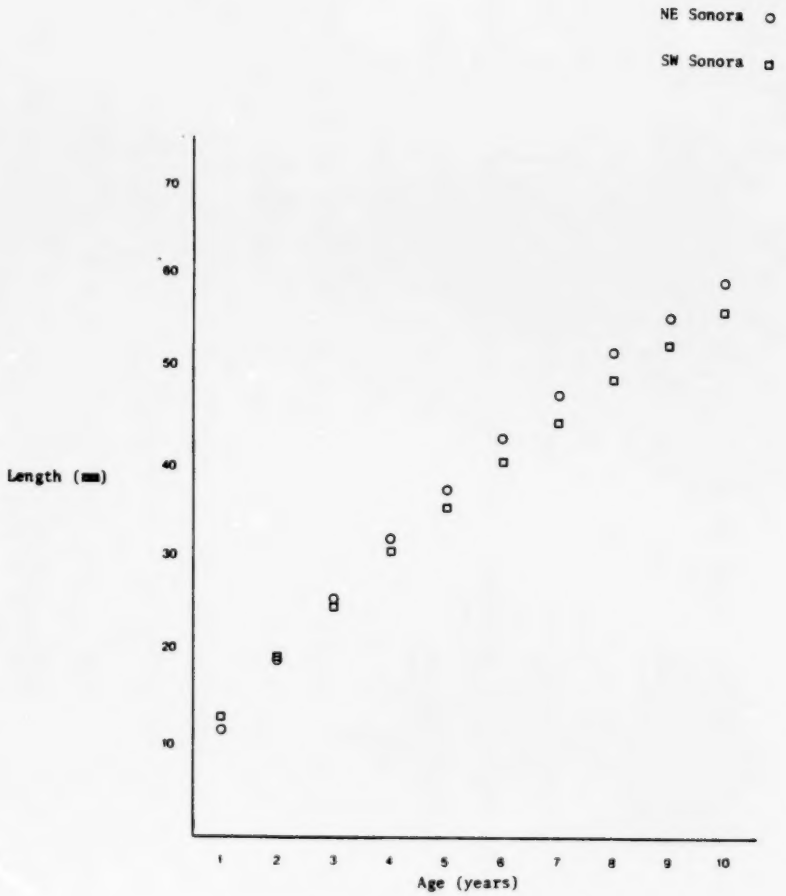

Figure 9: Growth curves for two locations at Sonora fitted by the von Bertalanffy growth equation.

growth rates were exhibited in W Chezzetcook than in E Chezzetcook (Figure 8). The differences might be attributed to substrate type as clams from the west side were taken from a muddy flat, while on the east side the areas were sandy. Belding (1916) stated that mud clams grow more slowly. Growth rates in Sonora (Figure 9) differ slightly between the mouth and further up the estuary. In general these surveys found that growth rates in both estuaries were highest upstream in sandy substrates. This may be reflective of better environmental conditions which might include higher temperatures, nutrients, and water flow, producing greater concentrations of available food and hence faster growth.

3.5 Reproduction

Time and situation did not allow monitoring of meat condition except on an observational basis. A large proportion of clams in Sonora had spent gonads at the end of July. Spawning in Chezzetcook Harbour occurred sometime between mid-July and mid-August. Assuming five weeks for larval development (Brousseau, 1978b), settlement of young would probably occur throughout September in both estuaries. Burke and Mann (1974) in 1972 at Petpeswick Inlet, observed only one major peak of settlement which occured in the month of September. This harbour is the next one to the east of Chezzetcook. Other authors have recorded one period of spawning a year, in the Bay of Fundy (Battle, 1933) and in P.E.I. (Robert, 1981).

Table 15. Average catch per unit effort (C.P.U.E.) for clam diggers interviewed on the Eastern Shore, and estimated harvests (bushels), 1981.

Location	W Chezzetcook	E Chezzetcook	Sonora
Average Tide (hours)	3	3	2
C.P.U.E. buckets/hr.	1.97	1.07	2.49
buckets/tide	5.90	3.20	4.98
Estimated Actual Harvest (A)	1,528.0	364.7	1,462.5
Estimated Potential Harvest (B)	5,135.5	894.9 (NE) 4,183.7 (NE + SE)	4,900.3
$\Sigma (\frac{A}{B} \times 100)$	30	41 (NE) 9 (NE + SE)	30

Table 17. Estimated landings* (Chezzetcook Harbour) and buyer reported landings (Sonora, Musquodoboit Harbour, Clam Harbour and Petpeswick), for soft-shell clams in metric tons (shell weight) from 1978 to 1981 along the Eastern Shore of Nova Scotia.

	Landings						
	District 17	District 20					
Year	Sonora	Chezzetcook W	Chezzetcook E	Musquodoboit Harbour	Clam Harbour	Petpeswick	Total
1981	40+	42x	10x	58+	47+	4+	201
1980	118+						
1979	19⊕						
1978	2⊕						

*Up to and including the month of November for 1981.

⊕Buyer estimates.

xCalculated from catch and effort statistics (estimates).

+Accurate records from buyers.

Estimated value of one metric ton is $678.34.

Table 16. Landings* (metric tons shell weight) of soft-shell clams in statistical districts along the Eastern Shore from 1952 to the present.

Year	District 17	District 20	Total
1981*	0	21	21
1980	23	2	25
1979	0	13	13
1978	7	1	8
1977	12	0	12
1976	6	0	6
1975	6	0	6
1974	8	0	8
1973	22	0	22
1972	4	2	6
1971	26	<1	26
1970	2	0	2
1969	1	0	1
1968	1	<1	1
1967	<1	0	<1
1966	3	27	30
1965	<1	5	5
1964	3	34	37
1963	5	13	18
1962	4	20	24
1961	8	3	11
1960	17	<1	17
1959	20	<1	20
1958	18	0	18
1957	6	0	6
1956	0	5	5
1955	24	10	34
1954	48	23	71
1953	84	133	217
1952	77	624	701
Total	436	938	1374

+ Taken from Table 3, Landings by Statistical District and Port, Statistics Division of Fisheries and Oceans.

* Printout Nov. 23 (may not be complete).

3.6 Catch and Effort Data

Table 15 presents catch and effort data which was calculated from 23, 8 and 20 fishermen interviews in W Chezzetcook, E Chezzetcook and Sonora, respectively. Buckets per hour are greater in Sonora (2.49) than Chezzetcook (1.07 - 1.97), suggesting higher stock densities in Sonora already confirmed by survey results. Based on information of catch rates (5 buckets per hour) from buyers and clam diggers in Musquodoboit and Clam Harbours, these areas had even greater stock densities in 1981. Assuming equal numbers of diggers, each of Chezzetcook and Musquodoboit Harbours should then have higher total landings than Sonora based on longer tides alone. This is substantiated by catch figures in Table 17. Overall exploitation rate would appear to be greatest in NE Chezzetcook (41%), assuming SE Chezzetcook is essentially unexploited. This is not surprising considering the combination of longer tides and relatively high accessibility.

3.7 Landing Statistics

Landing statistics are tabulated by Fisheries and Oceans through buyers' sales slips. Table 16 is a summary of these landings by fisheries district on the Eastern Shore from 1952 to the present.

The values are known to be underestimates since most catches are not reported due to private selling and sales to other parts of the Maritimes. In 1981, only 10% of the total landings were reported to Fisheries and Oceans

(Tables 16 and 17). At Sonora during 1980, 23 of the estimated 118 metric tons of clams actually landed were officially recorded. However, historical information from buyers and diggers indicate that these landings may reflect relative changes in catches and therefore abundance of clams. Personal communications with people involved in the clam fishery before the 1950's give support to the fact that landings and efforts at that time were very high and in fact were able to support processing plants in Musquodoboit, Clam and Chezzetcook Harbours. Statistics of the early 1950's are compatible with this information. One local buyer commented that he doubted if the landings on the Eastern Shore are now 10% of what they were before the 1950's. Catches (personal communications) declined in Musquodoboit Harbour from 80 buckets per tide at that time, to 30 buckets per tide in the 1960's (averaged for 100 diggers), to 15 buckets per tide at present for each of approximately 10 diggers. At Sonora during the 1950's, 40 buckets per tide on the average were harvested by each of 60 diggers (personal communication). In relative terms, the Eastern Shore has not been as productive since that time.

Fisheries statistics show that about twice as many clams were reported from District 20 (East Ship Harbour to Cole Harbour) as District 17 (Country Harbour to Ecum Secum), since the 1950's (Table 16). The first district includes Clam, Musquodoboit, Petpeswick, Chezzetcook and Cole Harbours, and the second Wine Harbour and Sonora. For

1981 (Table 17) landings in District 20 have tripled those in District 17, which might be attributed to a greater resource base and possibly greater market demand from the Halifax - Dartmouth area.

The statistics also show a 7-10 year periodicity of higher landings. Whether this phenomena is natural or fishing-induced is difficult to postulate.

More accurate accounts of catch statistics for the Eastern Shore (Table 17) give an estimated landing of 201 MT shell weight for 1981. This represents approximately 20% of the total clams recorded for all of Nova Scotia. Presently, it appears that the Eastern Shore is experiencing a period of relatively high catches; however, landings (personal communications) are down in Chezzetcook and Sonora (Table 17) from last year. Therefore, it is possible that catches along this shore may decline in the next few years, particularly if fishing effort continues to increase.

4. Discussion

Instantaneous population surveys are useful to describe the present status of stocks, but without comparative information from the past it is difficult to make predictions about the future situation or to recommend management stratagies.

The following interpretation of the survey results is therefore a conservative assessment of future status of the stocks. Management recommendations presented are those likely to be successful under ideal conditions of participant protection and cooperation.

Fishing intensity at Chezzetcook Harbour during 1981 appeared to be higher and stock densities lower than at Sonora. Recent years of excellent production of young should increase abundance and harvest in 6 to 7 years at Chezzetcook, thus offsetting the higher levels of exploitation there. At present harvesting rates, stock abundance is likely to decline at Sonora.

Long term stability of this fishery is related to annual success of juvenile production, which in turn is affected by natural or man-made disasters and indirectly by heavy fishing. Since growth rates are so slow (6 to 7 years to reach market size), any future lowering of juvenile survival will produce even longer term effects on brood stocks and numbers of clams available for harvest. Recent (1945-1974), expansion of marsh grass in W Chezzetcook (Scott, 1980) has resulted in a reduction of the area available for clam digging. This is another factor which can increase pressure on existing stocks and therefore affect future recruitment to the commercial fishery.

The clam fishery on the Eastern Shore was substantially more important prior to the 1950's after which, it is believed, overfishing reduced stock abundance to significantly lower levels. In 1981 the fishery supported approximately 41 full-time diggers and three buyers plus many others on a part-time basis. It was worth approximately $136,346 in the shell, which is likely an underestimate as the value of the part-time and recreational diggers plus the resultant tourist dollars cannot be assessed. Statistical data indicates

that catches have fluctuated since the 1950's. This variation in stock abundance and resultant exploitation is harmful not only to the resource, but also to the future success of the fishery and the people employed in it. The present situation is likely to continue; in fact, stocks may again be on the downward trend.

The goals of any fisheries biologist are to minimize fluctuations of stock numbers and increase harvest by proper management techniques. Based on this aim, the following management recommendations are made:

1. Clams are sexually mature after 40 mm and fecundity increases as they grow larger (Brousseau, 1978 b). Harvesting practices removes animals that are most sexually productive. Brood stock areas closed to fishing may be biologically and managerially acceptable as a means of helping to stabilize larval recruitment in estuaries.
2. Slow growth rates indicate that animals are still increasing in weight well past market size. Natural mortality rate is low after sexual maturity (Brousseau 1978a) and therefore gains by growth would outweigh losses by death. The size, at which maximum yield by weight is achieved, can be modelled, if sufficient biological parameters are available. This size is likely to be above the present harvest size of 49 mm (2"). Therefore future increases in weight harvested

may be made by gradual increases in the size limit.

3. Consideration for controls on catch or effort could be made; however, these would be difficult to enforce.
4. Improvements in landing statistics coupled with regular population surveys and catch sampling programs would aid in the proper knowledge and management of the resource.

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APPENDIX 1

Details of acreage and sampling stations, frequency distributions and number /ft.^{2} by size class, for all clam-producing areas surveyed in Chezzetcook Harbour, 1981.

Table A1.1. Size and number of sampling stations for the clam producing areas in W Chezzetcook.

Area #	Size ft.^{2}	Size m^2	acres	Number of sampling stations
1	888,324	82,558	20.40	81
2	163,778	15,221	3.76	15
3A	121,211	11,265	2.78	12
3B	45,665	4,244	1.05	9
4A	4,659	433	0.11	1
4B	166,048	15,432	3.81	24
5	74,233	6,899	1.70	8
6	1,152,396	107,100	26.45	119
7	641,468	59,616	14.73	117
8	112,248	10,432	2.58	8
9	158,871	14,765	3.65	18
10	503,998	46,840	11.57	66
11	120,135	11,165	2.76	37
12A	24,500	2,277	0.56	7
12B	2,389	222	0.05	4
13A	28,686	2,666	0.66	12
13B	17,098	1,589	0.39	5
13C	8,963	833	0.21	3
14	3,583	333	0.08	6
15A	9,566	889	0.22	7
15B	21,757	2,022	0.50	13
16	2,270	211	0.05	1
17	33,238	3,089	0.76	15
18	5,143	478	0.12	4
Total	4,310,227	400,579	98.95	592

Table A1.2. Size and number of sampling stations for the clam producing areas in NE Chezzetcook.

Area #	Size ft.^{2}	Size m^2	acres	Number of sampling stations
1	128,873	11,977	2.96	31
2	24,985	2,322	0.57	11
3	27,255	2,533	0.63	10
4	127,194	11,821	2.92	21
5	222,710	20,698	5.11	23
6	73,523	6,833	1.69	9
24	13,622	1,266	0.31	9
25	9,802	911	0.23	6
Total	627,964	58,361	14.42	120

Table A1.3. Size and number of sampling stations for the clam producing areas in SE Chezzetcook.

Area #	Size ft.^{2}	Size m^2	acres	Number of sampling stations
7	106,040	9,855	2.43	22
8A,B	296,589	27,564	6.81	31, 8
9	58,696	5,455	1.35	12
10	157,677	14,654	3.62	17
11	22,951	2,133	0.53	7
12A	14,461	1,344	0.33	6
12B,C,D	76,149	7,077	1.75	15, 15, 11
13	24,748	2,300	0.56	8
14	25,706	2,389	0.59	12
15A	142,613	13,254	3.27	17
15B	2,507	233	0.06	2
16	10,039	933	0.23	7
17	13,988	1,300	0.32	4
18	56,307	5,233	1.29	10
19	5,853	544	0.13	4
20	1,668	155	0.04	1
21	11,352	1,055	0.26	4
22	3,583	333	0.08	3
23	6,574	611	0.15	2
Total	1,037,501	96,422	23.80	218

Table Al.4. Size frequency distribution of the clams sampled by location in Chezzetcook Harbour.

Size Class (mm)	(inches)	Clams found in samples W Chezzetcook Number	%	NE Chezzetcook Number	%	SE Chezzetcook Number	%
0-16	<3/4	2696	19	487	14	1188	16
17-22	3/4	3554	25	749	22	1239	17
23-29	1	2936	21	946	28	1364	18
30-35	1 1/4	1679	12	465	14	1032	14
36-41	1 1/2	1232	9	286	8	898	12
42-48	1 3/4	951	7	238	7	851	11
49-54	2	479	3	129	4	492	7
55-60	2 1/4	245	2	58	2	276	4
61-67	2 1/2	128	<1	30	<1	82	1
68-73	2 3/4	37	<1	6	<1	28	<1
≥74	≥3	7	<1	0	0	10	<1
Total		13,944	100	3,394	100	7,460	100

Table Al.5. Summary of the size frequency distribution for Chezzetcook Harbour.

Size Class (mm)	(inches)	Clams found in samples Number	%
0-16	<3/4	4371	18
17-22	3/4	5542	22
23-29	1	5246	21
30-35	1 1/4	3176	13
36-41	1 1/2	2416	10
42-48	1 3/4	2040	8
49-54	2	1100	4
55-60	2 1/4	579	2
61-67	2 1/2	240	1
68-73	2 3/4	71	<1
≥74	≥3	17	<1
Total		24,798	100

Table Al.6. Number/ft.^{2} (.09 m^2) in each size/class for the three locations at Chezzetcook Harbour.

Size Class (mm)	(inches)	W Chezzetcook number/ft.^{2}	NE Chezzetcook number/ft.^{2}	SE Chezzetcook number/ft.^{2}
0-16	<3/4	4.55	4.06	5.47
17-22	3/4	6.00	6.24	5.71
23-29	1	4.96	7.88	6.29
30-35	1 1/4	2.84	3.88	4.76
36-41	1 1/2	2.08	2.38	4.14
42-48	1 3/4	1.61	1.98	3.92
49-54	2	0.81	1.08	2.27
55-60	2 1/4	0.41	0.48	1.27
61-67	2 1/2	0.22	0.25	0.38
68-73	2 3/4	0.06	0.05	0.13
≥74	≥3	0.01	0.00	0.05
Total		23.55	28.28	34.39

Table A1.7. Number/ft.^{2} (.09 m^2) in each size class by area, for W Chezzetcook.

Size class (inches)	(mm)	1	2	3A	3B	4A	4B	5	6	7	8	9	10	11	12A	12B	13A	13B	13C	14	15A	15B	16	17	18
<3/4	0-16	1.98	7.27	2.92	3.44	0	3.42	0	3.52	7.01	3.75	1.39	4.77	5.32	11.00	1.00	3.17	3.20	2.00	1.5	2.43	6.77	0	10.00	17.00
3/4	17-22	3.05	13.33	3.08	5.33	0	9.04	0.38	3.44	9.51	0.88	1.83	3.74	5.59	6.29	0.50	3.08	4.20	0	0.67	3.29	9.08	1.00	29.13	24.75
1	23-29	3.36	10.27	1.17	3.22	0	10.00	0.25	3.98	5.60	0.88	2.28	4.02	5.16	7.00	0.25	4.50	6.60	0	0.50	4.57	10.69	0	17.20	5.75
1 1/4	30-35	2.37	5.13	0.75	1.22	2.00	5.63	0.13	2.30	2.95	0.50	1.22	3.03	3.27	2.43	0.50	9.67	4.80	1.00	0.33	1.57	6.92	0	1.20	0.75
1 1/2	36-41	1.43	3.73	0.67	1.89	2.00	3.67	0	1.70	2.29	0.63	0.83	1.38	2.49	3.00	0.75	12.00	1.80	0.67	0.33	2.57	5.23	0	0.33	0
1 3/4	42-48	0.80	2.87	0.42	2.44	6.00	2.50	0.13	1.50	1.62	1.00	0.61	0.80	2.49	2.43	1.75	9.67	2.40	0	0.67	3.71	2.54	2.00	0	0.25
2	49-54	0.43	0.80	0.42	1.11	1.00	0.96	0.38	0.72	0.97	1.00	0.67	0.52	1.03	0.71	1.50	3.92	1.80	0.67	1.17	1.00	1.15	1.00	0	0
2 1/4	55-60	0.20	0.73	0.17	0.89	0	0.42	0.13	0.38	0.52	0.75	0.78	0.26	0.41	0.29	1.00	1.42	0.40	1.00	1.17	0.29	0.15	0	0	0
2 1/2	61-67	0.14	0.13	0.17	0	0	0.13	0.25	0.24	0.28	0.50	0.39	0.15	0.08	0.29	0.50	0.50	0	0.33	0.83	0.14	0.46	0	0	0
2 3/4	68-73	0.02	0	0	0	0	0.21	0.3b	0.08	0.06	0.50	0.06	0.08	0	0	0	0	0	0	0.17	0	0	0	0	0
≥3	≥74	0	0	0	0	0	0	0.13	0	0.02	0.13	0	0.05	0	0	0	0	0	0	0	0	0	0	0	0
Juveniles		19.76	36.00	7.92	13.21	2.00	28.09	0.76	13.24	25.07	6.01	6.72	15.56	19.34	26.72	2.25	20.42	18.80	3.00	3.00	11.86	33.46	1.00	57.53	48.25
		78.1%	81.3%	81.1%	67.6%	18.2%	78.1%	35.2%	74.1%	81.3%	57.1%	66.8%	82.8%	74.8%	79.9%	29.0%	42.6%	74.6%	52.9%	40.9%	60.6%	77.8%	25.0%	99.4%	99.5%
Prerecruits		2.23	6.60	1.09	4.33	8.00	6.17	0.13	3.20	3.91	1.63	1.44	2.18	4.98	5.43	2.50	21.67	4.20	0.67	1.00	6.28	7.77	2.00	0.33	0.25
		16.2%	14.9%	11.2%	22.2%	72.7%	17.1%	6.0%	17.9%	12.7%	15.5%	14.3%	11.6%	19.3%	16.2%	32.3%	45.2%	16.7%	11.8%	13.6%	32.1%	18.1%	50.0%	0.6%	0.5%
Markets		0.79	1.66	0.76	2.00	1.00	1.72	1.27	1.42	1.85	2.88	1.90	1.06	1.52	1.29	3.00	5.84	2.20	2.00	3.34	1.43	1.76	1.00	0	0
		5.7%	3.8%	7.8%	10.2%	9.1%	4.8%	58.8%	8.0%	6.0%	27.4%	18.9%	5.6%	5.9%	3.9%	30.7%	12.2%	8.7%	35.3%	45.5%	7.3%	4.1%	25.0%	0%	0%
Total		13.78	44.26	9.77	19.54	11.00	35.98	2.16	17.86	30.83	10.52	10.06	18.80	25.84	33.44	7.75	47.93	25.20	5.67	7.34	19.57	42.99	4.00	57.86	48.50
		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table A1.8. Number/ft.^{2} (.09 m^2) in each size class by area for NE Chezzetcook.

Size Class (inches)	(mm)	1	2	3	4	5	6	24	25
<3/4	0-16	3.10	0.64	8.70	9.90	0.78	0.33	0.11	11.17
3/4	17-22	6.23	0	14.90	12.95	3.78	1.11	0	8.00
1	23-29	8.35	1.27	15.60	14.95	6.13	2.00	0.33	6.83
1 1/4	30-35	2.71	0.27	4.70	8.19	4.96	1.11	0.67	4.83
1 1/2	36-41	1.26	0.18	2.20	5.52	3.09	0.55	1.00	3.67
1 3/4	42-48	0.68	1.27	1.70	4.24	3.13	0.22	0.56	3.00
2	49-54	0.58	0.82	2.10	1.19	1.13	0.44	1.00	2.83
2 1/4	55-60	0.29	1.27	0.60	0.29	0.39	0.66	0.44	0.67
2 1/2	61-67	0.16	0.64	0.40	0.19	0.17	0.33	0.33	0
2 3/4	68-73	0.03	0.18	0.30	0	0	0	0	0
≥3	≥74	0	0	0	0	0	0	0	0
Juveniles		20.39	2.18	43.90	45.99	15.65	4.55	1.11	30.83
		87.2%	33.3%	85.7%	80.1%	66.4%	67.4%	25.0%	75.2%
Prerecruits		1.94	1.45	3.90	9.76	6.22	0.77	1.56	6.67
		8.3%	22.2%	7.6%	17.0%	26.4%	11.4%	35.1%	16.3%
Markets		1.06	2.91	3.40	1.67	1.69	1.43	1.77	3.50
		4.5%	44.5%	6.6%	2.9%	7.1%	21.2%	39.9%	8.5%
Total		23.39	6.54	51.2	57.42	23.56	6.75	4.44	41.00
		100%	100%	100%	100%	100%	100%	100%	100%

Table A1.9. Number/ft.^{2} (.09 m^2) in each size class by area for SE Chezzetcook.

(inches)	(mm)	7	8A,B	9	10	11	12A	12B,C,D	13	14	15A	15B	16	17	18	19	20	21	22	23
<3/4	0-16	5.32	4.15	4.25	12.88	7.43	4.17	3.61	5.25	5.50	7.76	0	9.14	3.25	6.00	5.25	1.00	0.50	3.00	2.00
3/4	17-22	6.77	5.90	3.17	13.35	4.14	2.83	4.27	6.00	6.00	3.82	0.50	3.57	7.75	9.50	3.25	2.00	0.75	1.33	7.50
1	23-29	4.05	6.26	4.67	12.41	3.86	4.67	4.17	9.38	10.08	3.41	4.00	7.43	20.25	9.70	6.00	0	1.00	0.67	8.00
1 1/4	30-35	3.55	4.33	2.25	7.29	3.86	3.00	3.17	7.88	9.17	2.94	2.00	4.71	20.25	6.20	8.25	0	2.50	1.33	4.50
1 1/2	36-41	3.91	3.46	1.25	5.24	1.71	3.33	3.12	6.63	6.00	3.47	4.00	3.86	21.00	6.50	3.25	3.00	1.00	2.67	8.50
1 3/4	42-48	4.05	2.03	2.08	4.00	2.43	5.00	3.61	9.38	5.75	2.65	1.50	4.86	12.25	5.80	2.25	3.00	4.75	3.67	10.00
2	49-54	2.55	0.77	1.17	1.24	0.43	3.33	2.44	6.00	3.17	2.35	1.00	3.29	8.00	2.50	1.00	5.00	1.25	4.00	7.00
2 1/4	55-60	1.68	0.38	1.00	1.35	1.00	1.00	1.59	3.17	0.92	1.18	1.00	1.71	3.25	0.80	1.00	3.00	1.25	1.33	5.00
2 1/2	61-67	0.45	0.13	0.50	0.29	0	0.50	0.37	0.50	0.42	0.59	0.50	0.71	0.75	0.10	0.75	0	0	1.00	1.50
2 3/4	68-73	0.45	0.05	0.08	0	0.71	0	0.05	0	0.17	0.24	0	0	0	0	0	0	0	0.33	0.50
≥3	≥74	0.09	0	0.17	0.18	0.29	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0
Juveniles		19.69	20.64	14.34	45.93	19.29	14.67	15.22	28.51	30.75	17.93	6.50	24.85	51.50	31.40	22.75	3.00	4.75	6.33	22.00
		59.9%	75.2%	69.6%	78.9%	74.6%	52.7%	57.7%	52.6%	65.2%	63.1%	44.8%	63.3%	53.2%	66.7%	73.4%	17.6%	35.8%	32.7%	40.4%
Prerecruits		7.96	5.49	3.33	9.24	4.14	8.33	6.73	16.01	11.75	6.12	5.50	8.72	33.25	12.30	5.50	6.00	5.75	6.34	18.50
		24.2%	20.0%	16.2%	15.9%	16.0%	29.9%	25.5%	29.5%	24.9%	21.5%	37.9%	22.2%	34.4%	26.1%	17.7%	35.3%	43.4%	32.8%	33.9%
Markets		5.22	1.33	2.92	3.06	2.43	4.83	4.45	9.67	4.68	4.36	2.50	5.71	12.00	3.40	2.75	8.00	2.75	6.66	14.00
		15.9%	4.84%	14.2%	5.3%	9.4%	17.4%	16.9%	17.8%	9.9%	15.3%	17.2%	14.5%	12.4%	7.2%	8.9%	47.1%	20.8%	34.5%	25.7%
Total		32.87	27.46	20.59	58.23	25.86	27.83	26.40	54.19	47.18	28.41	14.50	39.28	96.75	47.10	31.00	17.00	13.25	19.33	54.50
		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Appendix 2

Details of acreage and sampling stations, frequency distributions and number /ft.^{2} by size class, for all clam-producing areas surveyed at Sonora, 1981.

Table A2.1. Size and number of sampling stations for the clam producing areas in Sonora.

Area #	Size $ft.^2$	Size m^2	acres	Number of sampling stations
1	582,299	54,117	13.37	63
2	471,600	43,829	10.83	49
3	888,324	82,558	20.40	73
4	524,195	48,717	12.04	43
Total	2,466,418	229,221	56.64	228

Table A2.2. Size and number of sampling stations for the clam producing areas in NE Sonora.

Area #	Size $ft.^2$	Size m^2	acres	Number of sampling stations
1	582,299	54,117	13.37	63
3	888,324	82,558	20.40	73
Total	1,470,623	136,675	33.77	136

Table A2.3. Size and number of sampling stations for the clam producing areas of S Sonora.

Area #	Size $ft.^2$	Size m^2	acres	Number of sampling stations
2	471,600	43,829	10.83	49
4	524,195	48,717	12.04	43
Total	995,795	92,546	22.87	92

Table A2.4. Size frequency distribution of the clams sampled by area at Sonora.

Size Class (mm)	(inches)	Clams found in samples Area 1 Number	%	Area 2 Number	%	Area 3 Number	%	Area 4 Number	%
0-16	<3/4	84	11	103	17	107	9	90	19
17-22	3/4	107	14	73	12	163	14	84	18
23-29	1	108	14	64	11	237	21	50	11
30-35	1 1/4	73	9	52	9	141	12	56	12
36-41	1 1/2	89	11	80	13	108	10	53	11
42-48	1 3/4	145	18	90	15	168	15	75	16
49-54	2	89	11	77	13	137	12	31	7
55-60	2 1/4	55	7	38	6	52	5	16	3
61-67	2 1/2	32	4	18	3	19	2	12	3
68-73	2 3/4	4	<1	3	<1	1	<1	2	<1
≥74	≥3	0	0	3	<1	0	0	0	0
Total		786	100	601	100	1133	100	469	100

Table A2.5. Summary of the size frequency distribution of the clams sampled for all areas in Sonora.

Size Class (mm)	(inches)	Clams found in samples Number	%
0-16	<3/4	384	13
17-22	3/4	427	14
23-29	1	459	15
30-35	1 1/4	322	11
36-41	1 1/2	330	11
42-48	1 3/4	478	16
49-54	2	334	11
55-60	2 1/4	161	5
61-67	2 1/2	81	3
68-73	2 3/4	10	<1
≥74	≥3	3	<1
Total		2,989	100

Table A2.6. Number/ft.^{2} (.09 m^2) in each size class by area, at Sonora.

Size class (inches)	(mm)	1	2	3	4
<3/4	0-16	1.33	2.10	1.47	2.09
3/4	17-22	1.70	1.49	2.23	1.95
1	23-29	1.71	1.31	3.25	1.16
1 1/4	30-35	1.16	1.06	1.93	1.30
1 1/2	36-41	1.41	1.63	1.48	1.23
1 3/4	42-48	2.30	1.84	2.30	1.74
2	49-54	1.41	1.57	1.88	0.72
2 1/4	55-60	0.87	0.78	0.71	0.37
2 1/2	61-67	0.51	0.37	0.26	0.28
2 3/4	68-73	0.06	0.06	0.01	0.05
≥3	≤74	0	0.06	0	0
Juveniles		5.90 47.4%	5.96 48.6%	8.88 57.2%	6.50 59.7%
Prerecruits		3.71 29.8%	3.47 28.3%	3.78 24.4%	2.97 27.3%
Markets		2.85 22.9%	2.84 23.1%	2.86 18.4%	1.42 13.0%
Total		12.46 100%	12.27 100%	15.52 100%	10.89 100%

Appendix 3

Length at age for soft-shell clams collected on the Eastern Shore for 1981.

Table A3.1. Length (mm) at age (years) for soft-shell clams collected at W Chezzetcook.

Age	Number of rings measured	Fitted Length[1]	Growth increment[2] $L_{t+1} - L_t$	Measured length
1	166	12.9	7	12.7
2	143	19.9	7	20.1
3	128	26.5	6	26.3
4	113	32.7	6	32.6
5	85	38.5	6	38.6
6	55	44.0	5	43.7
7	40	49.1	5	48.8
8	33	53.9	5	53.2
9	14	58.4	4	57.7
10	6	62.7	-	63.5
11	2	-	-	68.0
12	2	-	-	72.0
13	1	-	-	75.0

1. Determined from von Bertalanffy growth equation.
2. Growth increments calculated from fitted length.

Table A3.2. Length (mm) at age (years) for soft-shell clams collected at NE Chezzetcook.

Age	Number of rings measured	Fitted length[1]	Growth increment[2] $L_{t+1} - L_t$	Measured length
1	165	12.2	8	12.3
2	144	19.7	7	19.4
3	106	26.5	6	26.7
4	72	32.6	5	33.0
5	47	38.0	5	38.0
6	30	42.9	4	42.8
7	20	47.3	4	47.5
8	10	51.2	4	51.3
9	3	54.7	3	55.0
10	2	57.8	-	56.5
11	1	-	-	61.0

1. Determined from von Bertalanffy growth equation.
2. Growth increments calculated from fitted length.

Table A3.3. Length (mm) at age (years) for soft-shell clams collected at SE Chezzetcook.

Age	Number of rings measured	Fitted length[1]	Growth increment[2] $L_{t+1} - L_t$	Measured length
1	156	11.6	8	11.8
2	141	19.2	7	19.2
3	104	26.1	6	25.9
4	85	32.4	6	32.5
5	57	38.1	5	38.5
6	43	43.3	5	44.0
7	34	48.0	4	48.8
8	21	52.3	4	52.0
9	10	56.2	4	55.4
10	5	59.7	-	60.2
11	3	-	-	61.3

1. Determined from von Bertalanffy growth equation.
2. Growth increments calculated from fitted length.

Table A3.4. Length (mm) at age (years) for soft-shell clams collected at NE Sonora.

Age	Number of rings measured	Fitted length[1]	Growth increment[2] $L_{t+1}-L_t$	Measured length
1	444	11.4	8	11.4
2	420	18.9	7	18.9
3	115	25.7	6	25.6
4	89	31.9	6	32.0
5	70	37.6	5	37.7
6	53	42.9	5	42.6
7	32	47.7	4	48.0
8	10	52.1	4	52.5
9	4	56.1	4	56.3
10	1	59.8	-	56.0

1. Determined from von Bertalanffy growth equation.
2. Growth increments calculated from fitted length.

Table A3.5. Length (mm) at age for soft-shell clams collected at SW Sonora.

Age	Number of rings measured	Fitted length[1]	Growth increment[2] $L_{t+1}-L_t$	Measured length
1	203	12.7	6	12.6
2	153	19.0	6	18.8
3	128	24.9	6	25.0
4	107	30.5	5	30.4
5	84	35.6	5	35.3
6	50	40.4	4	40.1
7	26	44.8	4	45.0
8	16	49.0	4	49.0
9	9	52.9	4	51.4
10	4	56.9	-	57.0
11	1	-	-	62.0

1. Determined from von Bertalanffy growth equation.
2. Growth increments calculated from fitted length.